

# Emerging Trends in the Commercial Space Sector

## Need for Responsive Policy?

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# Goal of this Discussion

- Potentially burgeoning commercial space sector
- Explore/discuss scope of Agency regulatory role
  - Now
  - Future
  - Alternatives
- Questions to explore
  - Why (if) regulate these activities?
  - Who should regulate?
  - How to best do it to ensure national goals are met?
  - Where is burden of evidence?

# Emerging Commercial Activities in Space

In-Space Transportation—Landers, Rovers, and Orbiters

In-Space Human Habitats

On Orbit Servicing, Assembly, Manufacturing

On-Orbit Debris Removal

Space-Based Space Situational Awareness

Others (e.g., CubeSat based asteroid detection)

GPS Radio Occultation

Space-Based Frequency Mapping

Space-based Acoustic Sensing

- Are these activities covered under current authorities?
- If not, should they be? Is there a role for government given domestic and international laws and treaties?
- If so, is there a role for NOAA?
- Do any of these activities require legislation?

# NOAA and Remote Sensing

## NOAA

- NOAA is responsible for licensing private remote-sensing space systems
  - NOAA's regulations require licensees to provide and operate their systems within certain orbits, submit a plan for post-mission disposition of remote-sensing satellites, and provide a casualty risk assessment for planned post-mission disposals involving atmospheric reentry of the spacecraft
  - Presidential directive NSPD-27 (2003) [that set national policy on privately owned and operated remote sensing space systems] **does not define remote sensing**
  - Other NOAA documents have a very high level definition
    - “Remote sensing is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellites.”  
<http://oceanservice.noaa.gov/facts/remotesensing.html>
    - 15 CFR 960.3 emphasizes earth's surface
- Do activities above fall under NOAA's jurisdiction? (The authority was created for taking pictures)
- If not, then whose? (if anyone's)

## **FAA Office of Commercial Space Transportation (AST)**

- FAA is a regulator of space launch and reentry transportation carried out within the United States or by U.S. citizens
- FAA/AST exercises this responsibility consistent with public health and safety, safety of property, and the national security and foreign policy interests of the United States

## **Department of Commerce Office of Space Commerce**

- No current regulatory role

## **Federal Communications Commission (FCC)**

- FCC is responsible for efficient and effective use of non-Federal radiofrequency spectrum
- Internationally it promotes the growth and rapid development of innovative and efficient communication technologies and services
- It regulates satellite communications through the licensing of radio stations in outer space
- The FCC requires applicants to submit detailed information concerning plans for orbital debris mitigation. FCC licenses contain terms and conditions, such as specifying orbits and operating consistent with debris-mitigation plans.

# How to Determine Role(s) in this Fast-Changing Sector? First Principles?

- Do we need to define remote sensing better? So commercial space firms have a better sense of whether they will be regulated?
- Why regulate? What are we trying to protect and how?
  - Protect national security interests
  - International treaty compliance
- Do ALL activities need regulation? Are there any that we shouldn't be regulating anymore? Are there any missions that are “inherently governmental” that can only be performed for governments? Are there any areas where US pre-eminence is critical?
- Who should regulate? What timeframe?
  - NOAA, FAA, FCC, Commerce?
- How to best do it to ensure goals (which goals) are met?
  - Whose buy-in is required and who should just be informed?
- Where is burden of evidence?
  - Licensee? Government?
  - If government says no, what evidence?

# DETAILS ON ACTIVITIES

# On-Orbit Manufacturing

- Additive manufacturing/3D printing or in-space manufacturing using either materials from Earth OR materials extracted from space and processes in space
- Goals: exotic fiber, silicon carbide, replacement parts for satellites/ISS, full satellites, whole habitats/lunar bases
- *Made in Space* planning to make ZBLAN – at some point on a private station



Source: Made In Space, <http://www.madeinspace.us/projects/fiber/>



# On-Orbit Assembly

- Use of a space-based platform to assemble entire satellites or satellite components
- Space System Loral attempting to assemble antennae on to comsats



Photo credit: Space System Loral

# On-Orbit Servicing

- Four types:
  - End-of-life extension modules
  - Satellite repairs
  - Satellite refueling (Earth fuels)
  - Satellite refueling (from LEO depots of space-derived fuels)
- Orbital ATK – MEV to provide additional power/life extension
- Chandah Space – inspect client GSO satellites
- Space System Loral to provide additional transponders antennae



# On Orbit Proximity Operations

- Commercial smallsats provide rendezvous and proximity operations (RPO) services to larger satellites

Chandah Space plans to put smallsats (called InsureSats) in orbit above geosynchronous orbit (GSO) to come down and **inspect client GSO satellites using optical payload.**



Source: <https://www.nasa.gov/press-release/nasa-successfully-launches-noaa-advanced-geostationary-weather-satellite>

# Space-Based Space Situational Awareness

- Use of space-based sensors to provide awareness of the space environment (other satellites, debris, space weather events, etc.) for satellite operators
- Several companies have plans to place SSA sensors on satellites
  - Planetary Resources
  - Northstar
  - SpaceX
  - Other?

# In-Space Transportation—Landers, Rovers, and Orbiters

- Transport of goods or people to the Moon, Mars, space habitats, or asteroids
- Astrobotic
- Moon Express
- Masten
- SpaceX



Photo credit: Astrobotic



# In-Space Habitats

- Habitats to host crew in LEO, or eventually during Mars missions
- Two types: follow-on to ISS, or transportation capsules (to ISS) that could be used as standalone habitats
- Axiom Space
- Bigelow

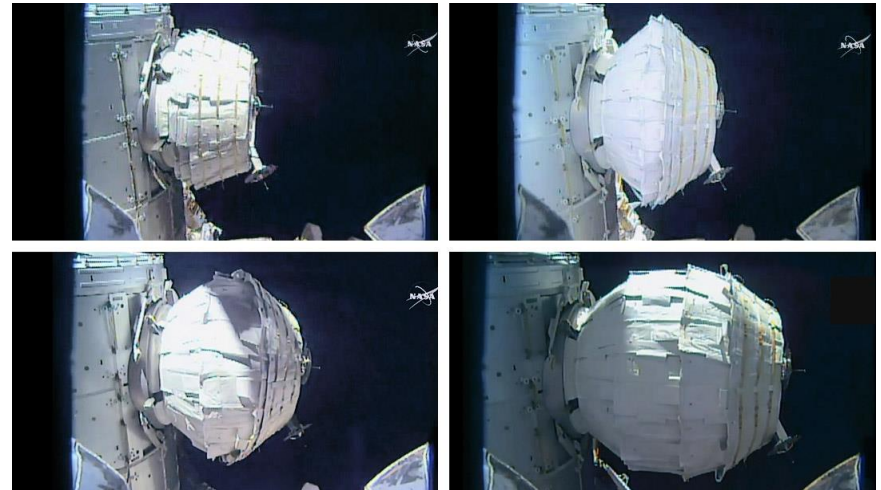


Photo credit: NASA TV

# Active (or Passive) Debris Removal

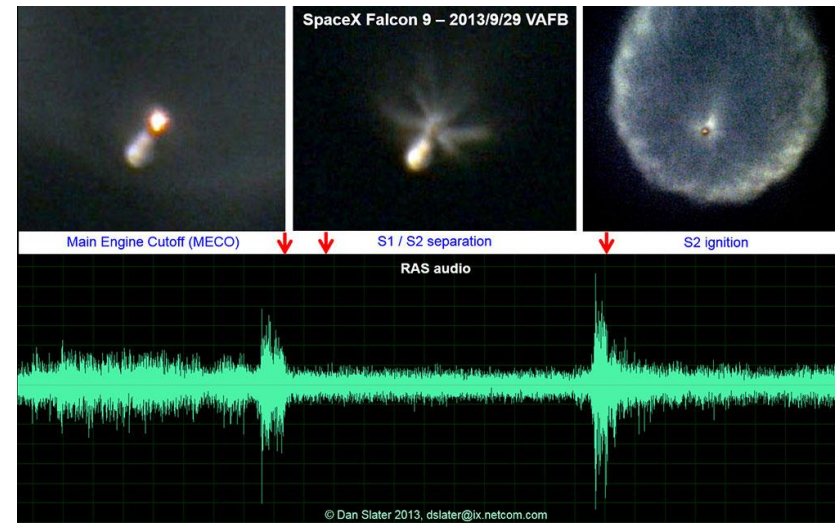
- Technologies to remove dangerous pieces of debris from crowded and/or valuable orbits
- Lasers, tethers, claws, solar sails. Most untested but increase in demand likely
- On-orbit servicing modules could also perform debris removal
- Launchspace Technologies
- Astroscale (Singapore/Japan)
- Ball Aerospace, Astra LLC developing M&S tools



# Space-Based Acoustic Sensing

- Use of advanced optical sensors to view and recover audio from distant objects that have weak optical modulations produced by local sound and vibration sources
- The modulated light sources and the RAS sensor are passively coupled at the speed of light, yielding a variety of interesting sounds across the entire human auditory range
- Ecliptic Enterprises Corp.
  - 3U CubeSat platform “RASSat” to listen to objects from space using cameras

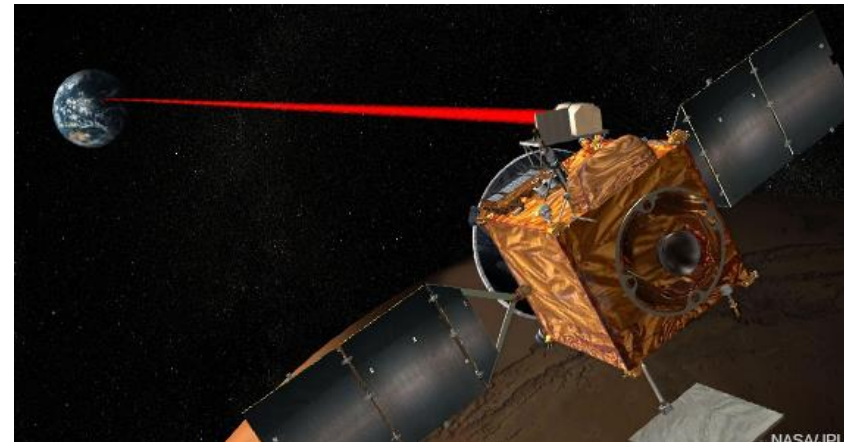
SpaceX F9 Rocket Staging at >100 km (>60 miles)





# Other Areas - Optical Communications

- Laser-based optical communications has been demonstrated in space and offers advantages over RF
  - Faster throughput
  - Fewer spectrum allocation issues at least in the near-term
  - Reduced satellite SWAP
- Beaming laser energy between space and ground will present new regulatory challenges, e.g.,
  - Deconfliction with terrestrial activities
  - Maximum power levels
  - Effects of atmosphere, weather
- NASA-MIT/LL Lunar Laser Comms Demo (2013)
  - Moon to Earth laser comm
- NASA-JPL Optical PAYload for Lasercomm Science (2014)
  - ISS to Earth laser comm
- NASA-GSFC Laser Comms Relay Demo (2019)
  - Commercial hosted payload



# DEFINING “COMMERCIAL”

# Defining “Commercial”

## **Commercial Space Policy Guidelines (1991)**

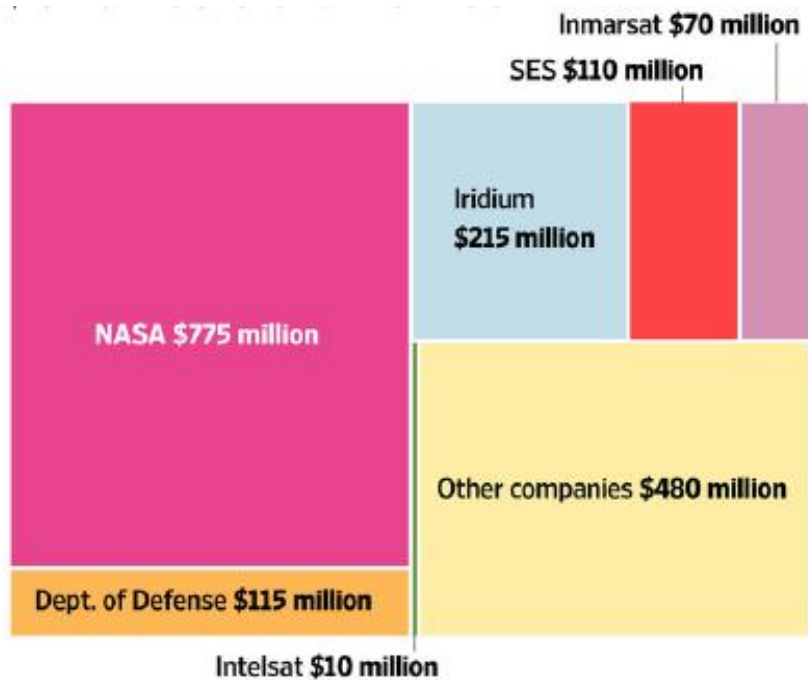
- Commercial space sector activities are characterized by the provision of products and services such that:
  - private capital is at risk;
  - there are existing, or potential, nongovernmental customers for the activity;
  - the commercial market ultimately determines the viability of the activity; and
  - primary responsibility and management initiative for the activity resides with the private sector.

## **National Space Policy (2010)**

- The term “commercial” ...refers to space goods, services, or activities provided by private sector enterprises that bear a reasonable portion of the investment risk and responsibility for the activity, operate in accordance with typical market-based incentives for controlling cost and optimizing return on investment, and have the legal capacity to offer these goods or services to existing or potential nongovernmental customers

# What % of a “commercial” firm’s business can be government (and be still considered commercial)?

## SpaceX



Source: the company, early 2016 documents

THE WALL STREET JOURNAL.

~\$.89B (\$1.8B revenues), 2015

## Other Space Firms

- Lockheed Martin
  - ~\$36B (\$46B revenues), 2015
- Made in Space
  - Unknown but likely mostly govt

## Traditional Commercial

- DirecTV
  - \$33B (2014), almost all commercial
- GM
  - \$166B (almost all commercial **BUT bailed out by government - \$16B**)

# Operational Definition

Risk Taker	Private Entities/ Markets Takes Risk	<b>“Emerging” Commercial Space</b> <i>Space X, Bigelow</i>	<b>Commercial Space</b> <i>Virgin Galactic, Space X, Bigelow (future)</i> <i>Intelsat (current)</i>
	Government Takes Risk	<b>“Traditional” Commercial Space</b> <i>e.g., Lockheed Martin</i>	<i>e.g., Roscomos, Arianespace</i>
		Government Primary Customer	Government One of Many Customers
Customer Base			